DOCUMENT RESUME

ED 156 516 SE 024 500

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TITLE A Comparison of Mathematics and Science Teachers in Achieving Selected Teacher Competencies.
PUB DATE Mar 78
NOTE 15p.; Paper presented at the annual meeting of the American Educational Research Association (Toronto, Canada, March 27-31, 1978); Not available in hard copy due to marginal legibility of original document

EDRS PRICE MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS *Educational Research; Mathematics Education; *Mathematics Teachers; *Performance Based Teacher Education; Preservice Education; Science Education; *Science Teachers; *Secondary Education; Secondary School Mathematics; Secondary School Science; Student Teachers; *Teacher Behavior; Teacher Education; Teaching Skills

ABSTRACT

A logical model derived from Piaget, Gagne, and Ausubel was used to derive eight areas of teaching behaviors. A list of 74 teacher behaviors was generated to match the model. Behaviors were assessed in classroom settings for 150 secondary school mathematics and science student teachers. Paper-and-pencil measures were also employed. Data were divided into two sets: data from student teachers who completed study between 1973 and 1975 and data from those who completed study between 1975 and 1977. Data were analyzed (1) to ascertain behaviors hard and easy to obtain and behaviors of differential difficulty for mathematics and science teachers, and (2) to assess the change in student teacher performance after a competency-based model has been in place for a period of time. The need for logical models and empirical research to support competency-based programs is discussed. (MN)

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COMPARISON OF MATHEMATICS AND SCIENCE TEACHERS IN ACHIEVING SELECTED TEACHER COMPETENCIES

by

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Introduction

In the spring of 1973 a novel CBTE program for the preparation of pre-service secondary school science and mathematics teachers was instituted at the State University of New York at Albany. This program, the Albany Mathematics Science Teaching program (AMST), was based on a systems analysis model derived in large part from the theories and empirical work of Ausubel, Gagne and Piaget. The program, the systems analysis model and a matching evaluative instrument of teaching competencies were designed by researchers Farmer and Farrell.

This report is the third in a series of studies based on data collected on student performance in AMST. In a 1976 paper Farrell, Farmer and Clark described the development of the model and employed principle components factor analysis to ascertain inter-relationships among competencies appropriate to both science and mathematics teachers. Seven factors, each with items that had loading of at least .30, emerged from this analysis. Finally, analysis of the empirical versus the logical correspondences of competencies to components of the systems analysis model was described.

A follow-up study by Farmer, Farrell and Clark (1977) reported on the abilities of three paper and pencil pretests to predict classroom performance as measured by the AMST evaluation instrument. The three paper and pencil measures were the Myers-Briggs Type Indicator, the Mathematics (or Science) Inventory of Teacher Perceptions and the AMST Pre-Test. The basic finding was the relative independence of the ratings of teacher classroom behavior from the scores on the paper and pencil pretests. There was little consistent relationship between what students

SE 024 500

said they would do in a classroom situation and how they actually performed in student teaching. Also, personality dimensions as measured by the Myers-Briggs tell us little about what to expect from a person in a teaching situation.

As Farrell and Farmer conceptualized desirable teaching behaviors for mathematics and science teachers, they agreed that to a very large extent the same behaviors are appropriate for both groups. Thus, with few exceptions, they attempted to rate the same behaviors using the same criteria for rating in both mathematics and science. Previous reports of this research have been almost entirely based on combined ratings of mathematics and science teachers.

A question little considered in the recent movement toward competency based teacher education is whether some behaviors are harder or easier to attain in specific subject matter areas. To the degree that one teaches as one is taught, teaching behavior would be expected to interact with subject matter. Short stories in high school English classes are frequently discussed; mathematical formulas are less likely to be. Thus a behavior such as, "Shows skill in directing class discussions," may be more likely to be demonstrated in English. Of particular interest in this regard are the results of a discriminate factor-analysis run as a minor part of a previous study (1977). Four behaviors from the common set expected of both mathematics and science teachers showed significant differences (.01 level) in the performance of mathematics versus science teachers. One of the purposes of the present paper is to further compare the attainment of specific objectives by mathematics and science teachers and to consider why differences might exist.

A second purpose of this paper is to assess what happens to student teacher performance after a competency based model has been in place for a period of time. Previous reports of data in this project have been based on 100 student teachers

who completed the program from 1973 to 1975. Since that time data are available on 50 additional teachers who completed the program between 1975 and 1977. Does experience with the program lead to more attainment? Contrasts between earlier and later data are made to consider this question.

Sample

Data analyzed in this study were obtained from 150 secondary school mathematics and science student teachers from the State University of New York at Albany. SUNY Albany is a highly selective university. Students major in their subject matter field and come to the School of Education for the courses required for teacher certification. In this study data are divided into two sets. In set one are data from students who completed study between 1973 and 1975 and in set two are data on students between 1975-77. The total sample breaks down in the following way:

	Mathematics	Science	Totals
Set One: 1973-75	60	40	100
Set Two: 1975-77	21	29	50
Totals	81	69	150

Procedures

The theories of Ausubel, Piaget, and Gagne were used to generate key parts of a model which describes the teaching-learning act in junior and senior high science and mathematics. Theoretically, the model describes teaching and learning in any domain. From this model were generated 74 behaviors which teachers should be able to exhibit in the classroom. The conceptual model and the behaviors generated from the model have been more fully described in other work (1976, 1977). The model and the desired teaching behaviors were made explicit to undergraduate mathematics and science teacher education candidates during a four-week intensive training program prior to student teaching.

Behavior ratings were made by the mathematics and science college supervisors, the first two authors of this paper, and by the classroom cooperating teachers. Each student teacher was observed eight to ten times by the college supervisor and as many or more times by the cooperating teacher. Data relative to target behaviors were recorded in written form during each observation. Attempts to promote inter-observer reliability included (1) the use of written operational definitions of the competencies (2) periodic cross-checking of indicators and non-indicators (3) occasional simultaneous observations followed by comparisons of the written records and (4) observer conferences on inferences to be made whenever the data pattern was questionable.

At the end of the ten-week student teaching experience the college supervisor studied all data records and rated each student's performance on each behavior as either below, at or exceeding (very rare) criterion. Each student similarly rated his or her own performance prior to a private final evaluation conference where self and supervisor ratings were compared. A search for further data and/or reanalysis of previously considered data was used to resolve any differences. It should be noted that the ratings reported reflect only the behaviors of students successfully completing student teaching, since others were counseled out of the program prior to the final weeks of teaching.

A comparison was made of the percentages of mathematics versus science teachers (in set <u>one</u>) rated as having reached criterion level performance on each of the 62 behaviors expected of both kinds of teachers. Data on student teacher performance in 1973-75 (set one) was then compared with similar data for set two teachers (1975-77).

Results

In Tables 1 and 2 are behaviors in which the percent of mathematics and science teachers (set one) who attained criterion differed by 10 percent or more. Notice that the first three behaviors in Table 1 are related to retention and practice. Typically, there is more opportunity to observe these behaviors in a mathematics lesson than in a science lesson. The next two behaviors seem to form a second conceptual cluster related to improvement of attitudes toward content while the final behavior is not conceptually linked to any of these behaviors. On the other hand, the first six behaviors in Table 2 seem to form a conceptual cluster of lab-oriented, concrete, real world competencies in which criterion level performance in one competency is likely to result in similar achievement in one or more of the other behaviors of the cluster. The seventh and eighth behaviors have no strong conceptual links to any of these competencies.

Tables 3 and 4 describe changes in the performance of 1975-1977 teachers as compared with 1973-1975 teachers. Analysis of the diagonal cells in Table 3 indicates that those behaviors which were moderately difficult (15-59%) for the 1973-1975 sample did not remain at the same level of difficulty for the 1975-1977 sample. Rather these behaviors were more difficult for the 1975-1977 sample. Even some of those behaviors easiest to attain by the 1973-1975 sample became increasingly difficult for the 1975-1977 group. In Table 4 specific competencies which had shifted by 25 percent or more from set one to set two teachers are displayed. The first four competencies were moderately easy for set one since they were not attained by 0-29% of the student teachers. Notice that all of these behaviors increased in difficulty for the teachers in set two. Competencies five through nine were moderately to very difficult for set one and all increased in difficulty for set two teachers. There were no behaviors which were attained more

easily by set two teachers than by set one teachers.

Discussion

The results displayed in Tables 1 and 2 are an attempt to obtain information on the extent to which subject matter being taught interrelates with teaching behaviors. Of the total set of 62 common behaviors expected of both science and mathematics teachers, there was apparently little difference in difficulty of attainment in the case of 49 behaviors (79%). Of the other 13 behaviors, six were relatively more difficult for science teachers while seven were relatively more difficult for mathematics teachers to attain. It has already been noted that there is more opportunity to practice specific behavior in one subject matter area than in another. This might explain the superior performance of mathematics teacher on behaviors 1, 2 and 3 in Table 1 and the superior performance of science teachers on behaviors 1 through 6 and 9 in Table 2. Just as mathematics lessons include frequent attention to skill learning so science lessons more frequently include laboratory and demonstration activities. Farrell and Farmer reason that laboratory activity and the related demonstration mode are appropriate for both subject areas, though not to the same extent nor in identical ways. No doubt the modelling effects of the teacher's own previous experience as a recipient of instruction is another factor contributing to the observed difference. Behavior eight may be similarly explained since mathematics is often perceived as an "explanation of rules" subject while science may include more emphasis on discovery approaches. The remaining behaviors in Tables 1 and 2 are not so easily explained. Behavior 4 in Table 1 is moderately easy for both mathematics and science teachers. One possible explanation for the results is that the nature of the subject may cause science teachers to take attainment of this behavior for granted while mathematics teachers may work more systematically toward attainment. In similar manner, behavior 5 in Table 1, while difficult for all novice teachers, may be more readily attained by means of the use of the more carefully patterned examples traditionally employed in mathematics

lessons. Likewise, the nature of laboratory work and the need for the science teacher to keep track of equipment and small groups may create more opportunities for the disruptive student to engage in serious interruptions of the lesson. Thus, a difficult competency becomes tested even more severely. However, the established difference in attainment of this competency might well be a function of a failure to maintain inter-observer reliability despite the attempts described earlier. The same is probably true of competency 7 in Table 2 in which case we can offer no satisfying explanation of the noted difference.

The second purpose of this study was to identify the differences, if any, in the performance of two sets of teachers -- one from 1973-1975, the other from 1975-1977. Fifty-six percent (35) of the common behaviors remained at the same relative level of difficulty for both groups. As previously noted, the other twenty-seven behaviors (44%) became more difficult for the 1975-1977 teachers to attain. Table 4 lists those behaviors which declined the most (at least 25%). As can be seen, most of these behaviors (with the exceptions of 3 and 9) relate to the teacher's ability to respond to individual differences and to be flexible in reacting to pupil behavior in the classroom.

One can only speculate as to why these drastic declines occurred. At least two major factors may be interacting to produce the observed effect. One of these is the training effect of experience on the raters and the other is the changing talent pool.

The first factor concerns the quality and quantity of data being supplied by all raters -- both cooperating teachers and college supervisors. Cooperating teachers who have worked with AMST repeatedly have become clearer as to the indicators and non-indicators which define each competency and the need to supply sufficient data to support judgments. The college supervisors not only have

similarly profited from the long-term experience but also have developed instructional materials designed to specifically support the attainment of the desired behaviors. As a result, the college supervisors have developed increasingly clear notions of what constitutes criterion performance Therefore, borderline cases which were rated "at criterion" in 1973-1975 sample were probably rated "below criterion" in the 1975-1977 sample.

What is the character of the talent pool which completed AMST in 1975-1977 and how does it differ from the earlier group? Our data do show a decline in the number of students completing the program. The 100 students in set one were involved over a period of five semesters -- an average of twenty per semester. The fifty students in set two were involved over a period of four semesters -- an average of twelve and one-half per semester. There has been a comparable decline in the number of students entering the program since set one graduated. The comparison of grade point averages, always a somewhat suspect measure, has become entirely useless due to the well-publicised and real "grade inflation" existing throughout the nation. National test scores have showed a continued decline in the quality of the college population. To what extent is this quality decline reflected in the students who elected to pursue an intensive professional semester? There is a real possibility that the quality of the students entering the professional education sequence has suffered. In addition, the publicity citing the general over-supply of teachers may have caused the most able students to elect other options. It is argued that the very best students in mathematics and science are aware of the diverse options open to them whereas less able students tend to remain in the pool because of the lack of other alternatives. Turner (1975) cites the talent pool and the variables which affect its quality as one of the most critical problems in the improvement of teaching and the effectiveness of teacher

education programs.

Conclusion

The AMST evaluation instrument was designed to provide a profile of various ways in which individuals can exhibit teaching effectiveness -- rather than a check list of minimum competencies to be achieved at the mastery level. Thus, it is no surprise that the included behaviors range over the entire spectrum from the very easy to the very difficult to attain during a ten week student teaching experience.

A consideration of the results relative to mathematics versus science teacher performance suggests that some behaviors require intensive instructional inputs prior to the student teaching experience if previous experience and/or perceptions of subject matter constraints are to be overcome. According to Gage and Winne (1975), the empirical evidence to-date strongly supports the claim that novice teachers can be instructed in ways that bring about specified changes in their behavior. From a practical point of view, AMST instruction prior to and during student teaching might have to extend over a longer period of time if additional and difficult competencies were to be attained by more teachers.

Finally, the fact that some behaviors remained in the easy to moderate range across both samples may indicate the existence of a subset of competencies which should be insisted on as a bare minimum for initial certification. Other, more difficult, competencies may well be identified as a subset required to move from initial to more permanent forms of certification.

The data very clearly demonstrates that experience *per se* in a CBTE program does not result in greater attainment of competencies -- at least where a model other than one of the mastery type is employed.

BIBLIOGRAPHY

Andersen, D. W. et. al. Competency based teacher education. Berkley: Mc Cutchan Pub. Co., 1973.

Farmer, W. A. and Farrell, M. A. Pilot study in mathematics and science teacher education. School Science and Mathematics, December, 1972, 72, 772-776.

Farmer, W. A., Farrell, M. A. and Clark, R. M. Test competency as related to classroom performance (a research paper presented at the annual meeting of the New England Educational Research Association, May, 1977, Manchester, N.H.).

Farrell, M. A., Farmer, W. A. and Clark, R. M. Field testing a systems analysis model for mathematics/science teacher education (a research paper presented at the annual meeting of the National Council of Teachers of Mathematics, 1976, Atlanta, Ga.).

Gage, N. L. and Winne, P. H. Performance-based teacher education. In K. Ryan (Ed.), Teacher education (74th Yrbk. Part II of NSSE). Chicago: The University of Chicago Press, 1975.

National Council of Teachers of Mathematics. NCTM recommendations on competency-based teacher education. Washington, D.C.: NCTM, 1977.

Stone, J. B. The Albany and Rochester mathematics teacher education programs: a comparative case study. (Ed. D. dissertation). Rochester: The University of Rochester, 1976.

Turner, R. L. An overview of research in teacher education. In K. Ryan (Ed.), Teacher education (74th Yrbk. Part II of NSSE). Chicago: The University of Chicago Press, 1975.

TABLE 1

Behaviors Relatively More Difficult For Science Than For Math Students (1973-75)

Behavior	Percent Below Criterion: Mathematics	Science
1. Provided for and supervised student practice	0	10
2. Designed assignments which reinforced the concepts, rules, or skills taught in a previous class session	5	16
3. Used a variety of remedial procedures based on student feedback	34	65
4. Included objectives designed to effect positive attitudinal changes toward the subject matter	12	23
5. Designed assignments to lead to discovery of concepts, rules, or skills to be taught in subsequent class sessions	53	75
6. Demonstrated the ability to control disruptive student behavior	15	45

TABLE 2

Items Relatively More Difficult For Math
Than For Science Students (1973-75)

Behavior	Percent Not Attaining Mathematics	Science
1. Used real objects and/or physical models in demonstrations	23	10
2. Utilized laboratory activities	58	5
3. Demonstrated initiative in locating and using laboratory activities and demonstrations	56	10
4. Demonstrated ability to work with single students or small groups while exhibiting awareness of the general activities of the classroom	32	13
5. Arranged instructional modes so that student attention was maintained throughout the lesson	37	13
6. Provided applications of subject matter based on the "here and now" interests of individual students	42	10
7. Made immediate use of feedback to pace instruction	38	3
8. Asked thought-provoking and/or open-ended questions	60	35

TABLE 3

Changes in the Number of Below Criterion Ratings
of 1973-75 Versus 1975-77 Teachers

Percent Below Criterion 1973-75	Number of Behaviors	Percent Below Criterion 1975-77 (very easy) 0-14	15-29	30-44	45-59	(very difficult) 60+	Number of Behaviors
0-14	25	17	6	1	0	1	25
15-29	17	0	9	4	4	0	17
30-44	11	0	0	6	2	3	11
45-59	6	0	0	0	0	6	6
60+	3	0	0	0	0	3	3
Totals	62	17	15	11	6	13	62

(very easy) ↓ (very difficult)

TABLE 4

Behaviors Attained Twenty Five Percent
Or More Frequently By 1973-75 Than By
1975-77 Students

Behaviors	% Below Criterion 73-75	75-77	Change
1. Modified instructional materials to meet the special needs of the student and the limitations of the classroom	14	67	53%
2. Made immediate use of feedback to pace instruction	26	57	31%
3. Matched test items to instructional objectives	0	29	29%
4. Used school resources (e.g. pupil personnel services, teacher,etc.) to deal with individual differences	22	47	25%
5. Used a variety of procedures such as grouping within a class and/or assignment of individual or small group projects	38	67	29%
6. Used positive techniques to prevent and/or control student behavior	39	70	31%
7. Used a variety of remedial procedures based on student feedback	44	72	28%
8. Made immediate use of feedback to alter the planned instructional strategies	62	92	30%
9. Designed assignments to lead to the discovery of concepts, rules or skills to be taught in subsequent class session	62	88	26%